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Whitebark Pine as a Tree Island Initiator Understanding Its Role in Facilitation

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Treeline environments

- Treeline environments are climatically harsh.
- Soils are often nutrient-poor and unstable.
- Under stressful environmental conditions, facilitation between plant species, or a “nurse” object and a plant, may improve plant survival (e.g., Callaway et al. 2002, Brooker et al. 2007).
- These same processes will be essential at upper treeline limits for response to climate change.

Whitebark Pine at Treeline

- Inhabits upper subalpine and treeline throughout its distribution.
- Dispersed to treeline by nutcrackers.
- In the alpine–treeline ecotone (ATE), there is a mix of solitary krummholz trees and tree islands composed of two or more krummholz trees.
- Tree islands form when a solitary tree becomes established, and other trees establish leeward.

Our studies have found that whitebark pine on the eastern Rocky Mountain Front and in other regions serves as the majority tree island initiator.

Where is whitebark pine a tree island initiator?

- Standley Glacier, Kootenay NP
- Eastern Front, NW Montana
- Line Creek Research Natural Area, Wyoming Creek, Beartooth Plateau, Custer NF

Major associated species in Rocky Mountains:

- Subalpine fir (*Abies lasiocarpa*)
- Engelmann spruce (*Picea engelmannii*)

Where not a tree island initiator*?*

Resler and Tomback 2008, Smith-McKenna et al. in press, Tomback et al. in review

Example: Rocky Mountain Front, NW MT
Resler and Tomback (2008)

- Whitebark pine comprised 67% of solitary trees.
- Whitebark pine occurred in 96% of tree islands.
- Whitebark pine was found in the lee of shelter significantly more frequently than any other species.
- Whitebark pine was the “initiator” for 49% of all tree islands with multiple trees.

Implications

Whitebark pine helps develop vegetation spatial pattern at alpine treeline. Tree establishment often occurs in protected locations: lee of rocks, vegetation, patterned ground, depressions.

Blister rust at treeline

Rocky Mountain Front, initial exploratory sampling (2006)

- **Lee Ridge**
- **Divide Mountain**

33.7% overall of sampled treeline whitebark pine infected by blister rust. (Resler and Tomback 2008).

Recent sampling (2010, 2011):

- **Divide Mountain, 23.6%**
- **Line Creek RNA, 19.2%**

(McKenna-Smith et al., in press)

Results in loss of tree island initiator function.

Why is whitebark pine a majority tree island initiator?

Hypotheses

- Whitebark pine offers greater microsite protection than other conifer species.
- Whitebark pine has superior hardiness and growth under harsh conditions.

Microclimate and microsite

Pyatt et al. in prep.

Study areas--MT

- **Divide Mountain-**-straddles boundary between Glacier National Park and Blackfeet Tribal Land; elevation ca. 2,200 m.
- **Line Creek Research Natural Area**, Custer National Forest, Beartooth Plateau; elevation approx. 2,950 m)

Whitebark pine microsites predicted to have

- Attenuated air and soil temperatures with lower maxima, higher minimums, and lower variances.
- Higher soil moisture.
- Lower photosynthetically active radiation (PAR).
- Lower wind speeds and lower wind gusts.
- Lower percent sky exposure.
- Higher total carbon and nitrogen in soil.

Methods

- Microclimate recorded leeward of four microsites: whitebark pine, Engelmann spruce, rock, and open or unprotected microsite.
- Microsites grouped in blocks—2 or 3 blocks per study area.
- Microsite defined as a space 20 cm in diameter, no taller than 15 cm, directly leeward of a protective object.
- Leeward microsite estimated from wind-flagged branches of surrounding conifer tree islands.

In 2010, examined on NE and SW-facing slopes.

In 2011, 2012, same sites, examined on NE-facing slopes

Variables examined

Microclimate: air and soil temp., soil moisture, wind, PAR

- Onset Computer HOBO Dataloggers and sensors.
- Data taken at 15 minute intervals mid-July to mid-September 2010, 2011, 2012.

Sky exposure

- Sky exposure determined for each microsite using a 180º fisheye lens on a Nikon D50 digital camera.
- Percent cover was found digitally using Adobe Photoshop Elements 10 (2011).

Soil samples

- Soil samples from leeward of whitebark pine, Engelmann spruce, rock and unprotected microsites with a 2.56 cm-diameter soil corer.
- Each core was taken to the O horizon.
- Ten soil samples for each microsite type per study area.
- Analyzed for total carbon and nitrogen at the EcoCore Analytical Services Lab at Colorado State University.

Microclimate stations

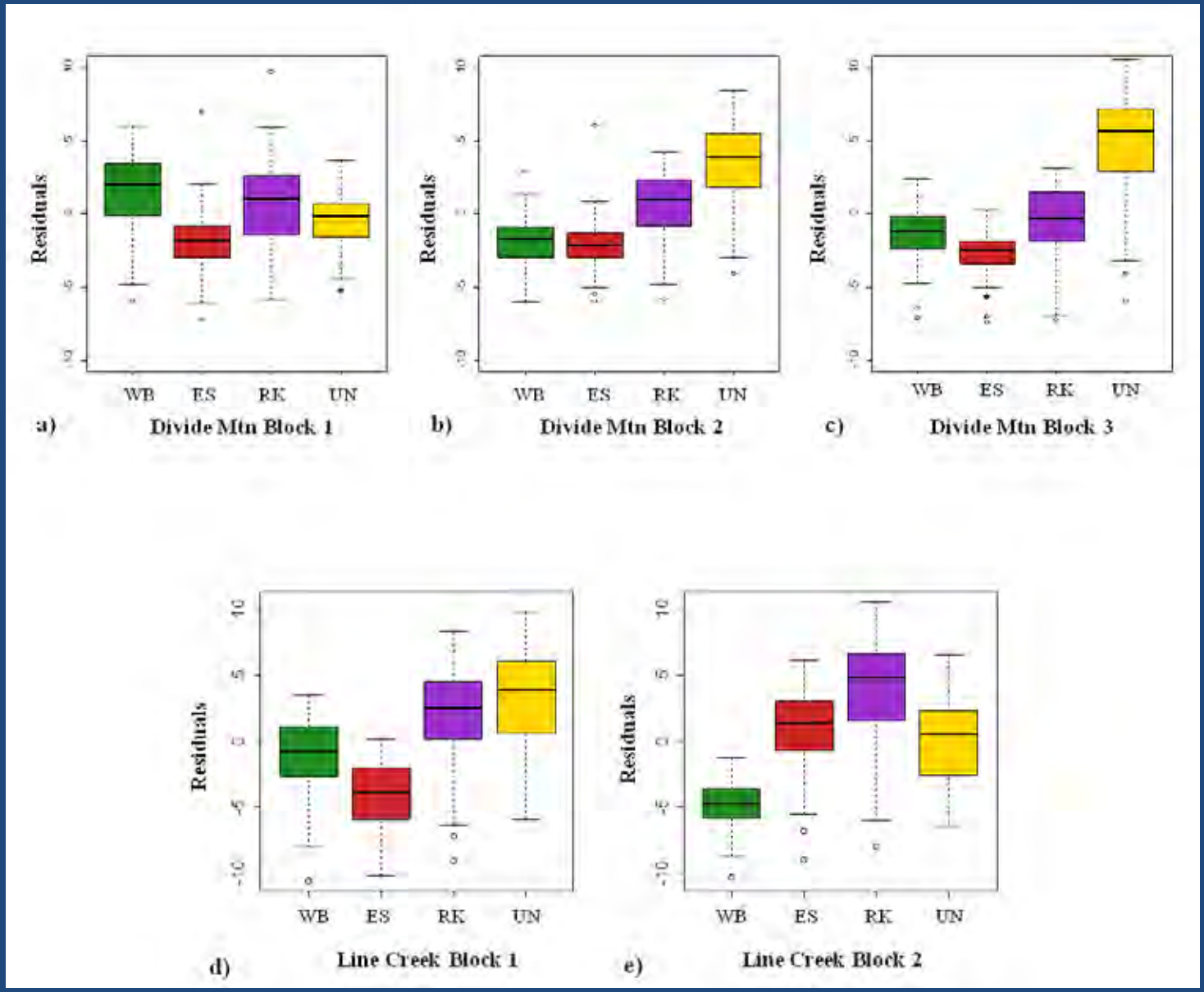
Focus:

2011, 2012: Divide Mtn.--3 blocks of microsites on NE aspect. Line Creek RNA--2 blocks of microsties on NE aspect.

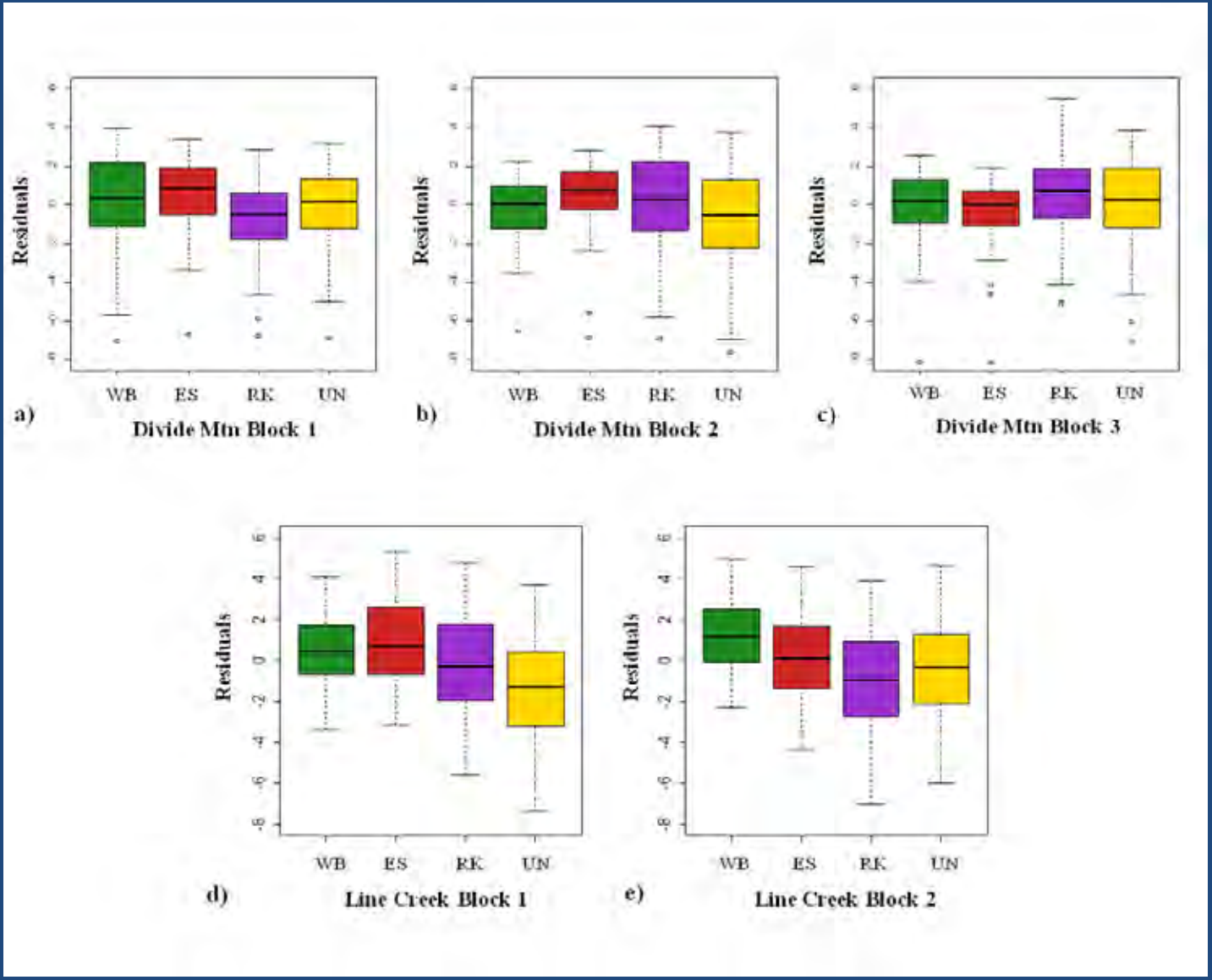
Analyses

- All analyses completed using R statistical software version 2.14.1 (R Core Development Team, 2011).
- The assumptions of normality and homoscedasticity were not met.
- Kruskal-Wallis one-way analysis of variance with pairwise Wilcoxon rank sum test for post hoc analysis.
- Variables that trended seasonally (temperature and PAR) were detrended by a quadratic or linear model of best fit.
- Residuals, representing the distance and direction from the mean, were used as a method for comparing deviations among microsite classes from the mean.

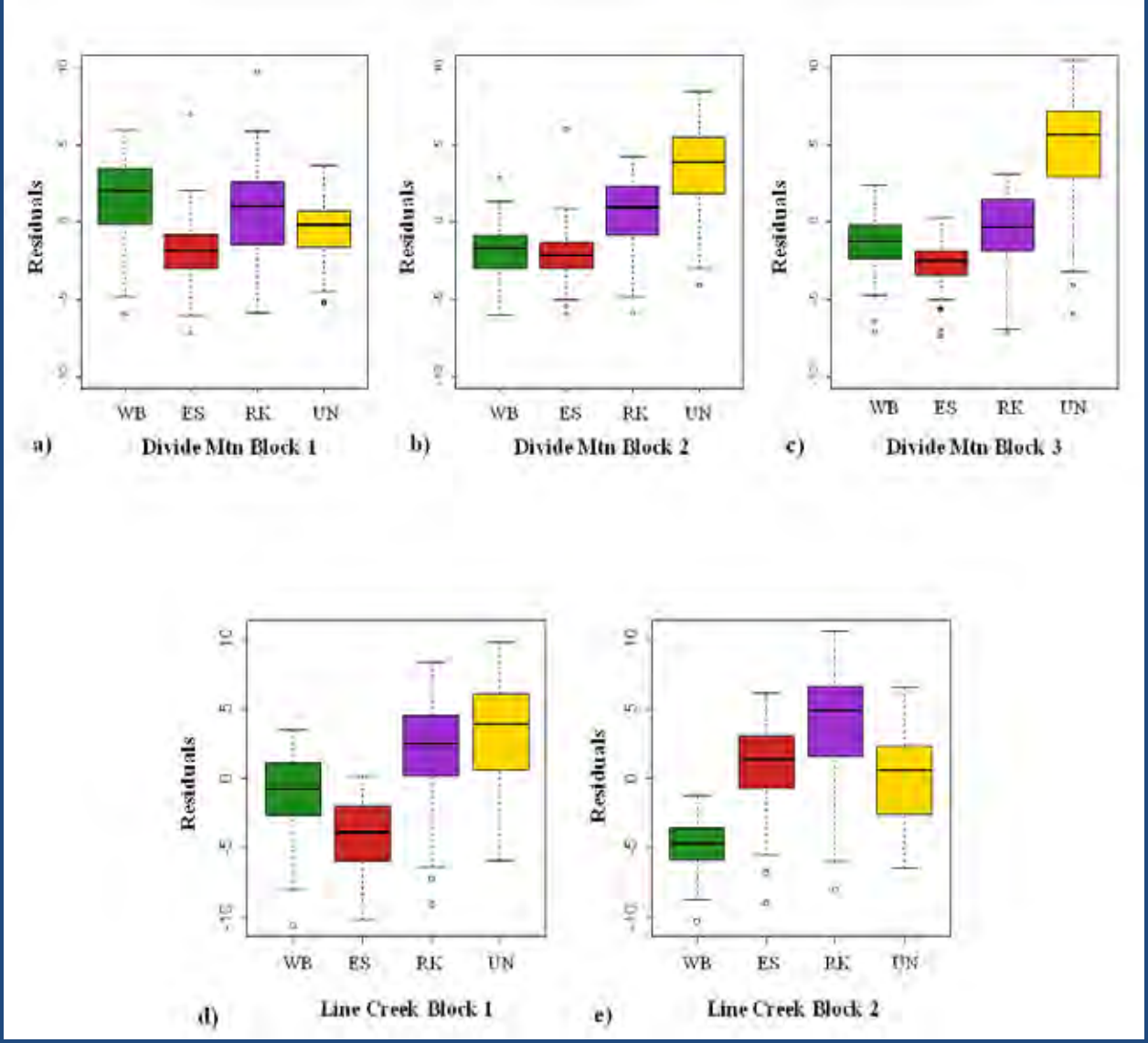
Example: 2012 daily max soil temp.



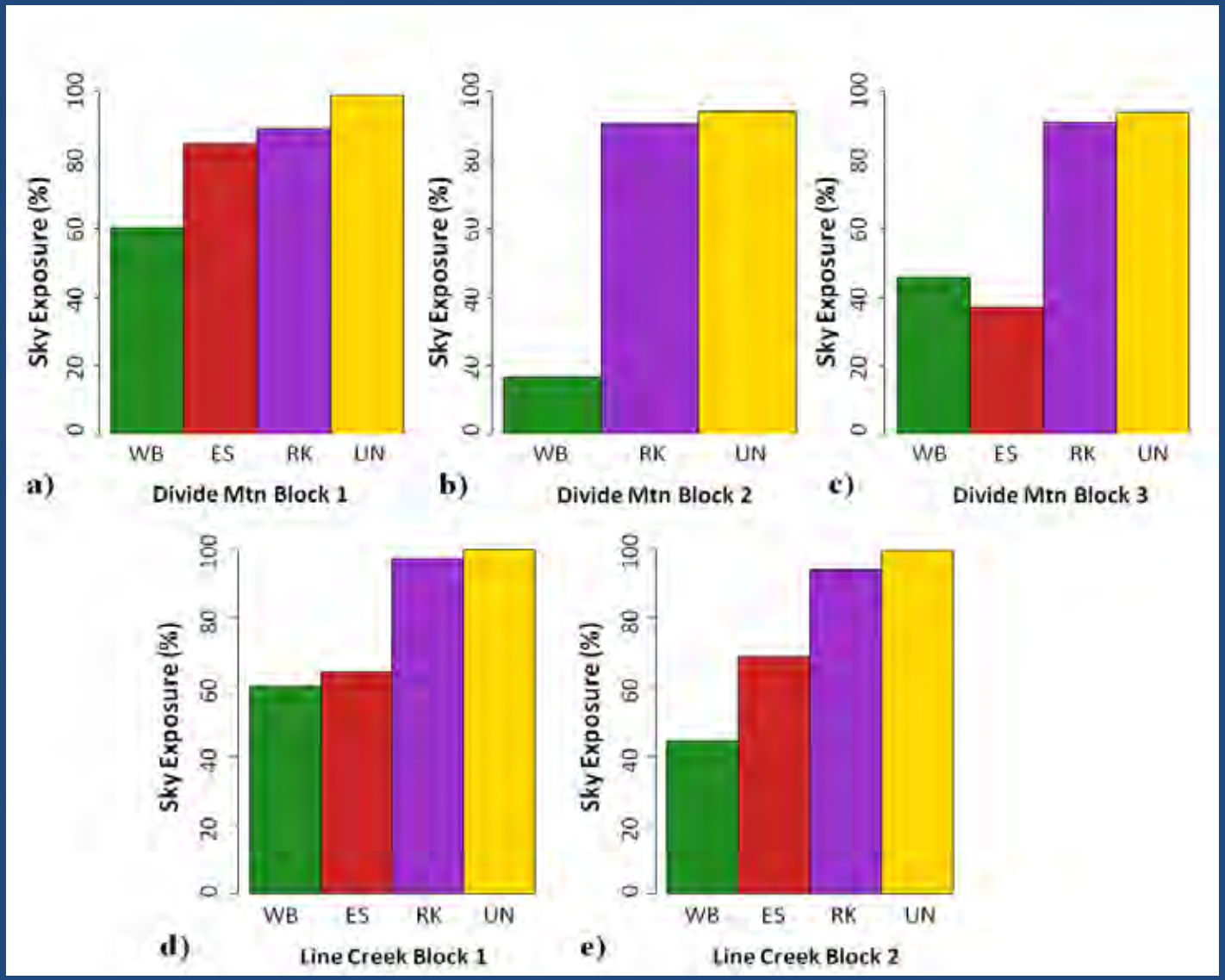
Example: 2012 daily min soil temp.



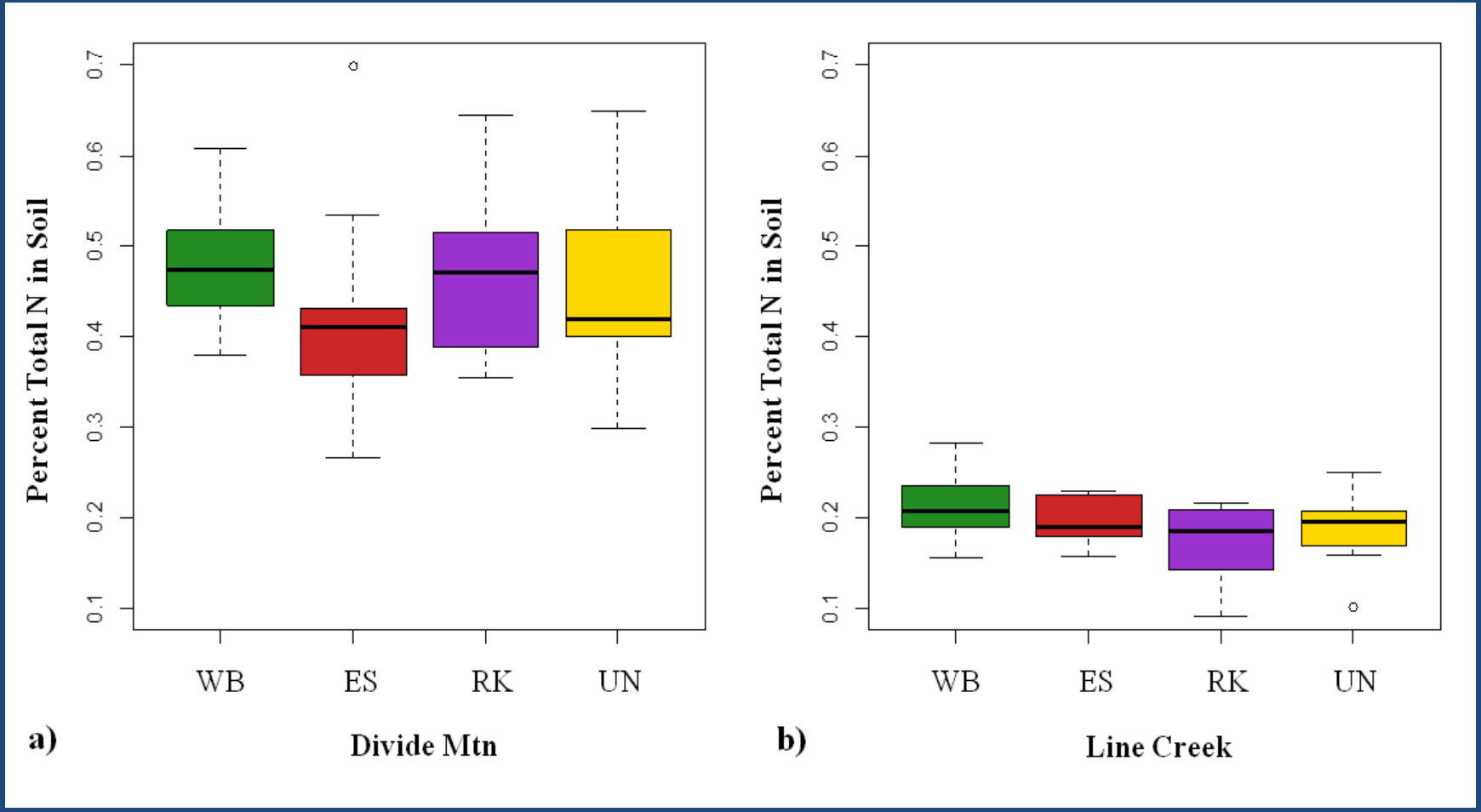
Example: 2012Daily max gust speed



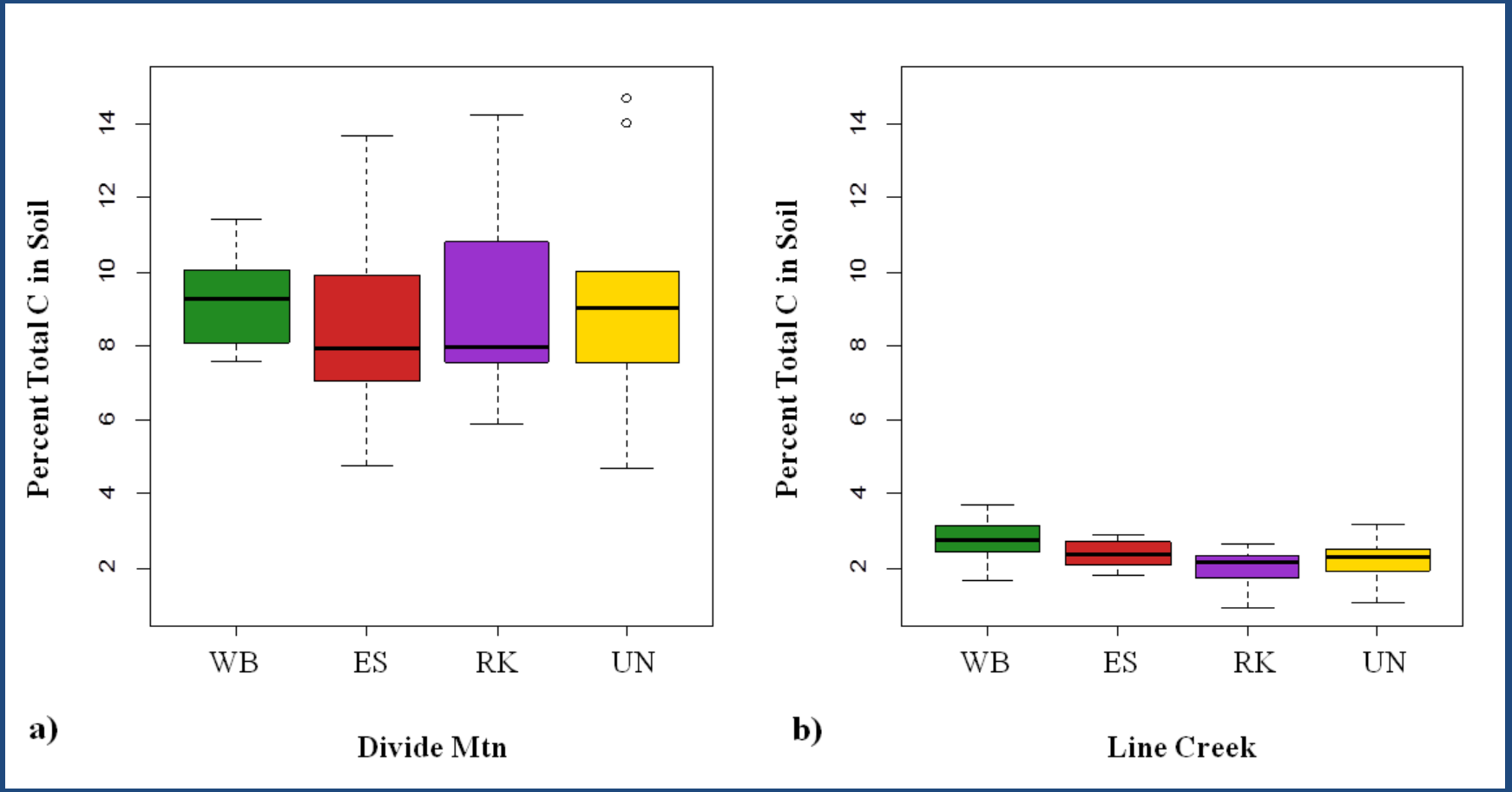
2011 Sky exposure



Percent total nitrogen in soil



Percent total carbon in soil



Microclimate and microsite: summary

Compared to rock and open microsites, conifer microsites generally had more favorable microclimates in their lee:

- Reduced maximum air and soil temperatures.
- Higher minimum soil temperatures.
- Lower PAR.
- Reduced wind and gust speeds.
- These differences were greatest under the harsher climatic regime of the Line Creek study area.

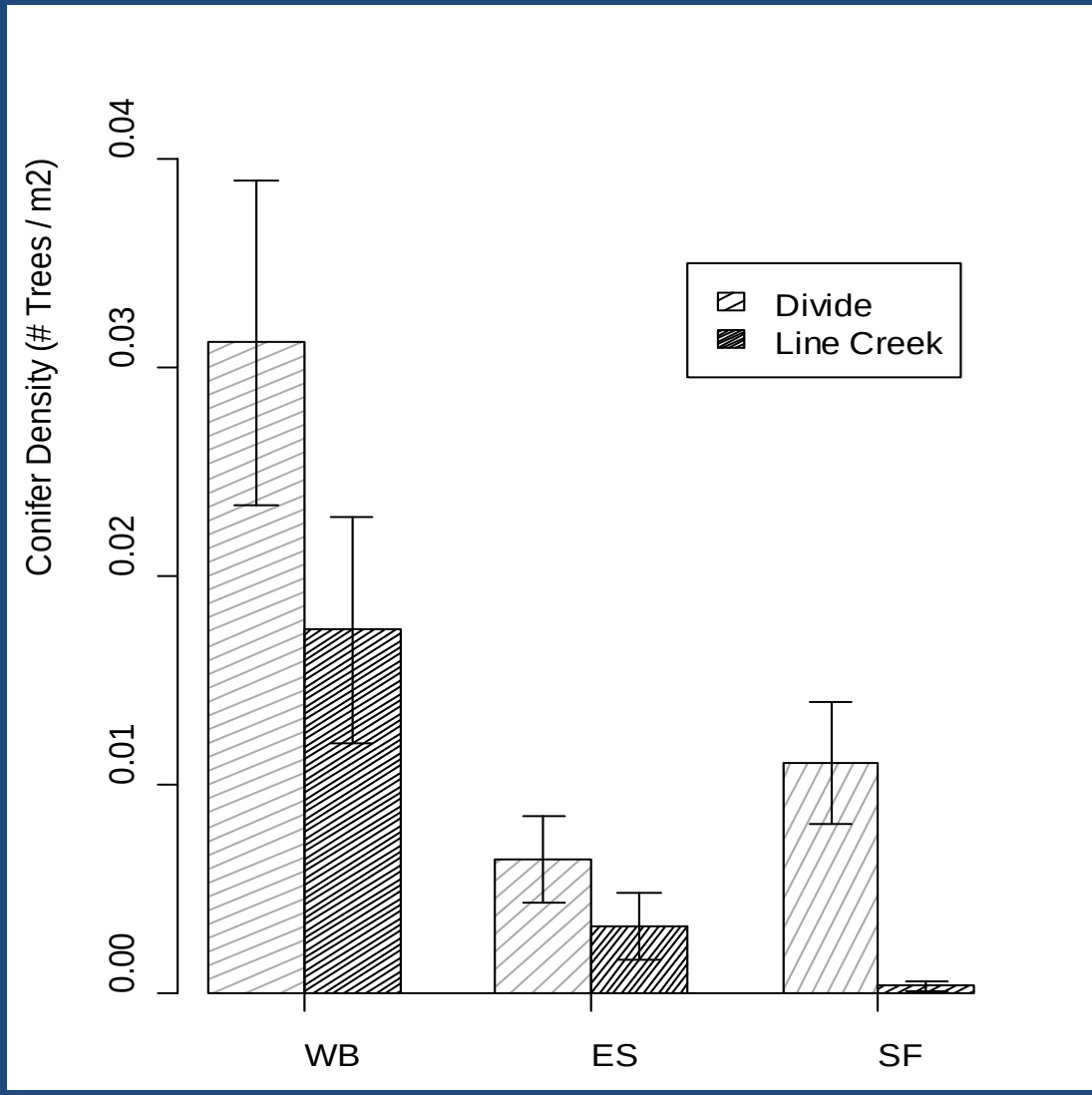
Whitebark pine microsites did NOT have a more favorable climate than spruce microsites, but

- Did show lower sky exposure in general.
- Soils in leeward microsites may have higher carbon and nitrogen content.

Abundance, growth and vigor:
Blakeslee et al. in prep.

More solitary whitebark pine than Engelmann spruce or subalpine fir.

- **N trees = 487 at Divide Mtn.**
- **N trees= 209 at Line Creek**



- Lengths of new shoot compared among whitebark pine, Engelmann spruce and subalpine fir.
- Whitebark pine produces significantly longer shoots at treeline.
- Whitebark pine had higher vigor than both fir (W = 19557, *P* = 0.037) and spruce (*W* = 13026.5, *P* = 2.08e-5) at Divide

Divide Mountain

Year	Length Spp., Mean (SE)	n	Species Comparisons	W -Statistic	P - Value
2011	WP 22.0 (2.93) ES 8.8 (0.85) SF 11.3 (1.56)	17 15 15	WB > ES WB > SF SF = ES	205 190 149	5.3e-4 0.006 0.14
2012	WP 28.7 (3.35) ES 9.3 (0.92) SF 11.0 (1.15)	17 15 15	WB > ES WB > SF ES = SF	349 192 82	6.1e-6 8.4e-5 0.36

Line Creek RNA

Year	Length Spp., Mean (SE)	n	Species Comparisons	W -Statistic	P - Value
2011	WP 48.1 (4.25) ES 22.9 (2.45) SF 27.6 (3.34)	21 12 20	WB > ES WB > SF SF = ES	36 36 149	2.8e-5 4.0e-4 0.36
2012	WP 70.16 (3.67) ES 26.24 (3.74) SF 23.99 (4.3)	21 12 20	WB > ES WB > SF ES = SF	16 220 90	1.0e-8 0.0004 0.35

Protective microsites

We found a statistical difference in the association between sheltering microsite and species.

- Divide Mountain: whitebark pine more often in minimally protective microsites (i.e., small ground terraces) and spruce and fir more often near rocks or vegetation ($\chi^2 = 9.769$, df = 2, $P = 0.008$).
- Line Creek RNA: similar differences were found in tree species and shelter type ($\chi^2 = 11.3217$, df = 2, $P = 0.003$).

Conclusions

Whitebark pine offers greater leeward microsite protection than other conifer species.

--Not supported, but conifers provide more moderated climate and more protection from wind than rock or exposed sites.

--Whitebark pine canopies may reduce sky exposure.

--Whitebark pine microsites may have higher total nitrogen and carbon.

Whitebark pine has superior hardiness and growth under harsh conditions.

--More abundant, higher vigor, longer shoot growth under harsh conditions.

--More individuals survive without facilitation.

Conclusions for our study areas

- Whitebark pine appears to be especially tolerant of harsh conditions.
- Appears to be an important nurse object.
- The loss of whitebark pine to blister rust will alter future composition and structure of treeline communities.
- May impact response of treeline to climate change.

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